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RESEARCH ARTICLE

# A cross-sectional study of association of body mass index and $VO_2$ max by nonexercise test in medical students

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## ABSTRACT

**Background:** There is an increasing trend of obesity and it affects the physical fitness and person's work output in medical students. $VO_2$ max indicates person's cardiovascular fitness. **Aims and Objectives:** (i) To evaluate the association between body mass index (BMI) and $VO_2$ max by nonexercise test using NASA/Johnson Space Centre physical activity-rating (PA-R) scale in medical students. (ii) To evaluate the effect of the gender on $VO_2$ max. (iii) To compare $VO_2$ max in obese and nonobese students. **Materials and Methods:** A total of 98 medical students aged between 17 and 19 years belonging to both the genders, were included for the study. The NASA/Johnson Space Centre PA-R scale was used for nonexercise protocol. $VO_2$ max was calculated taking into account subjects PA-R score, his BMI and gender: (i) Equation for male students: $VO_2$ max (ml/kg/min) = 67.350 – (0.381 × age [years]) – (0.754 × BMI) + (1.951 × PA-R), (ii) Equation for female students: $VO_2$ max (ml/kg/min) = 56.363 – (0.381 × age [years]) – (0.754 × BMI) + (1.951 × PA-R). Statistical analysis was performed using Pearson's correlation to know the association between BMI and $VO_2$ max. **Results:** The correlation factor for association between BMI and $VO_2$ max was significantly negative ($P < 0.001$). The values of $VO_2$ max were more in male gender and nonobese group. **Conclusion:** Increasing BMI affects the $VO_2$ max reducing the person's cardiovascular fitness. Lifestyle modification should be adapted to keep the check on BMI and to improve the cardiovascular fitness.

**KEY WORDS:** Body Mass Index; $VO_2$ max; Obesity; Physical Activity-rating Score

## INTRODUCTION

Due to modern day life, more and more people are adopting sedentary lifestyle. This sedentary life is making people overweight and obese. Obesity and cardiorespiratory fitness (CRF) are modifiable and independent risk factors for cardiovascular mortality. Obesity is a serious and widespread problem globally. Obesity can be assessed in several ways. Measurements of body mass index (BMI) reflect body fat in the form of overweight and obesity.[1]

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Physical fitness is considered as a degree to execute a physical task under various ambient conditions. It has five components: Aerobic capacity, muscular endurance, flexibility, and body composition. Maximal oxygen consumption is considered the gold standard of cardiopulmonary and muscle cell fitness. Maximal oxygen uptake ($VO_2$ max) is the highest rate of oxygen consumption attainable during maximal or exhaustive exercise.[1] The $VO_2$ max is basically affected by genetic factors, physical training, gender, age, and body composition.[2] Maximal oxygen consumption can be measured directly by open circuit spirometry in a laboratory. Where it is not feasible to use direct method, variety of submaximal or maximal indirect tests with controlled exercise

protocol can be used. There are also nonexercise methods to calculate the $VO_2$ max which takes into consideration person's characteristics such as age, sex, anthropometric measurements, history of physical activity or resting (PA-R) level physiological measurements.[3]

Measuring $VO_2$ max by exercise test is time-consuming and difficult to administer to large population. It also requires costly instruments and trained personnel. Compared to exercise test and nonexercise test are simple to apply and are cost-effective especially in low infrastructure sites.[4] Various nonexercise predictive models have been developed for estimation of $VO_2$ max. This nonexercise protocol can be used to assess CRF in epidemiological studies due to their feasibility.[5] One of the studies among medical students evaluated the validity of nonexercise test using the NASA/Johnson Space Centre PA-R scale compared to exercise the protocol using Queens's college step test. The study showed no statistically significant difference between $VO_2$ max obtained by both exercise and nonexercise protocols using PA-R scale.[4]

The study among healthy male subjects of 18-22 years had shown a negative association between $VO_2$ max and BMI suggesting increased BMI impairs cardiorespiratory functions and oxygen uptake by working muscles.[1,6] $VO_2$ max evaluated among medical students had shown the fitness level in fair category as compared with standard $VO_2$ max classification. This could be due to decreased physical activity and unhealthy lifestyle behaviors, overweight and obesity contributing for reduced $VO_2$ max.[7]

The prevalence of obesity and overweight has been increasing in medical students due to long sedentary lifestyle adopted to complete the syllabus. This sedentary lifestyle and physical inactivity lead to low level of aerobic fitness. Very fewer studies have evaluated CRF among medical students and its association with BMI. By knowing the aerobic fitness, students could be motivated toward physical activity. Keeping these things in mind, this study is undertaken with following objectives: (i) To know association of BMI and $VO_2$ max obtained by nonexercise test using the NASA/Johnson Space Centre PA-R scale among medical students, (ii) to evaluate the effect of the gender on $VO_2$ max, and (iii) to compare the $VO_2$ max in obese and nonobese students.

## MATERIALS AND METHODS

Study site: Belgavi Institute of Medical Sciences, Belgavi
Study design: Cross-sectional study
Sample size: 98 students of first year.
$n=z^2p\ q/d^2=96$ where z is value for α error
p= $VO_2$ max 48.9 ml/kg/min from the reference article [1]
q=100-p
d=absolute error 10%

A total of 98 medical students aged between 17 and 19 years belonging to both the genders, studying at Belgavi Institute of Medical Sciences, Belgavi, were included for the study after obtaining approval from institutional ethical committee.

### Inclusion Criteria

The medical students of age group of 17 and 19 years, who consented for the study.

### Exclusion Criteria

Students having a history of smoking, tobacco chewing and alcohol consumption, acute or chronic illness or any physical disability and those who were unwilling to take part in the study were excluded from the study. This cross-sectional study was conducted at the Department of Physiology. Informed written consent was obtained from all participants. Anthropometric measurements were done using the standard protocol.

### Parameters

Standard height of students was recorded without shoes and wearing light clothes. The measuring tape will be mounted on the wall to the nearest of centimeters (<5 and >5 mm). The weight was recorded with shoes off and with light clothes on a weighing machine with at least count of 500 g.

BMI: BMI was calculated by the formula: Weight (kg)/Height ($m^2$).

### Estimation of $VO_2$ Max by Nonexercise Protocol

The NASA/Johnson Space Centre PA-R scale was used for nonexercise protocol. This scale is developed to provide an assessment score of 0-7 depending on the person's level of routine physical activity. There are a series of eight statements about routine physical activity. Subject is required to select that best describes their physical activity level. Each statement is given a numerical value which is described as his PA-R score. $VO_2$ max was calculated taking into account subjects PA-R score, his BMI and gender: (i) Equation for male students: $VO_2$ max (ml/kg/min) = 67.350 − (0.381 × age [years]) − (0.754 × BMI) + (1.951 × PA-R); (ii) Equation for female students: $VO_2$ max (ml/kg/min) = 56.363 − (0.381 × age [years]) − (0.754 x BMI) + (1.951 × PA-R).[8]

### Statistical Analysis

Descriptive and inferential statistical analysis had been carried out in this study. Results on continuous measurements are presented on Mean±Standard deviation (Min-Max) and results on categorical measurements are presented in number

(%). A significance is assessed at 5% level of significance. Student *t*-test (two-tailed, independent) had been used to find the significance of study parameters on continuous scale between two groups (Intergroup analysis) on metric parameters. Pearson's correlation was used to evaluate the association between BMI and $VO_2$ max.

**Table 1:** Age and gender distribution of students studied

| Age in years | Gender | | Total (%) |
|---|---|---|---|
| | Female (%) | Male (%) | |
| 17 | 6 (15.4) | 16 (27.1) | 22 (22.4) |
| 18 | 22 (56.4) | 33 (55.9) | 55 (56.1) |
| 19 | 11 (28.2) | 8 (13.6) | 19 (19.4) |
| 21 | 0 (0) | 2 (3.4) | 2 (2) |
| Total | 39 (100) | 59 (100) | 98 (100) |

*P*=0.316, Not significant, student *t*-test

**Table 2:** Comparison of study variables in male and females studied (student *t*-test)

| Variables | Gender | | Total | P |
|---|---|---|---|---|
| | Female | Male | | |
| Age in years | 18.13±0.66 | 17.97±0.85 | 18.03±0.78 | 0.316 |
| Height (m) | 1.57±0.10 | 1.70±0.06 | 1.65±0.10 | <0.001** |
| Weight (kg) | 55.08±9.6 | 61.12±13.14 | 58.71±12.17 | 0.015* |
| BMI (kg/m$^2$) | 22.81±5.57 | 20.99±3.94 | 21.72±4.72 | 0.061+ |
| $VO_2$ Max | 37.01±4.92 | 52.15±4.53 | 46.12±8.79 | <0.001** |

+ Suggestive significance (*P*=0.05<*P*<0.10). *Moderately significant (*P*=0.01<*P*≤0.05); **Strongly significant (*P*≤0.01)

## RESULTS

The study was performed among 98 medical students of which 39 students were of female gender and 59 students were of male gender (Table 1). The mean age was 18.13 ± 0.66 in female students and it was 17.97 ± 0.85 in male gender. The mean BMI in female students was 22.81 ± 5.57 kg/m$^2$, and in male students, it was 20.99 ± 3.94 kg/m$^2$. There was no statistical difference in the age and BMI of both genders. The mean value of $VO_2$ max in female students was 37.01 ± 4.92 mlkg/min, and in male students, it was 52.15 ± 4.53 ml/kg/min. $VO_2$ max values in male students were more as compared to values in female students. The results were statistically significant ($P < 0.001$). The results are shown in Table 2. $VO_2$ max values of nonobese female students were fitting into fair to excellent category, whereas in male gender the $VO_2$ max values of nonobese group was falling in superior category as per the standard $vo_2$ max value classification.[9] The difference between $VO_2$ max values of obese and nonobese group was statistically significant in both genders ($P < 0.001$). The results are shown in Table 3. Pearson's correlation factor for the association between $VO_2$ max and BMI was negative, which was statistically significant ($P < 0.001$). The results are shown in Table 4.

## DISCUSSION

During exercise oxygen consumption matches to the energy expenditure up to a particular point. This $VO_2$ max denotes CRF of the individual.[6] Improvement in the fitness level has various positive effects on depression, anxiety, and

**Table 3:** $VO_2$ max distribution in obese and nonobese (Chi-square test/fisher exact test)

| $VO_2$ max (ml/kg/min) | BMI (kg/m$^2$) | | Total (%) | *P* |
|---|---|---|---|---|
| | Non-obese (%) | Obese (%) | | |
| Female | | | | |
| <25 (very poor) | 0 (0) | 9 (90) | 9 (23.1) | <0.001** |
| 25-30.9 (poor) | 0 (0) | 0 (0) | 0 (0) | |
| 31-34.9 (fair) | 1 (3.4) | 1 (10) | 2 (5.1) | |
| 35-38.9 (good) | 14 (48.3) | 0 (0) | 14 (35.9) | |
| 39-41.9 (excellent) | 11 (37.9) | 0 (0) | 11 (28.2) | |
| >41.9 (superior) | 3 (10.3) | 0 (0) | 3 (7.7) | |
| Total | 29 (100) | 10 (100) | 39 (100) | |
| Male | | | | |
| <35 (very poor) | 0 (0) | 0 (0) | 0 (0) | <0.001** |
| 35-38.3 (poor) | 0 (0) | 0 (0) | 0 (0) | |
| 38.4-45.1 (fair) | 0 (0) | 3 (30) | 3 (5.1) | |
| 45.2-50.9 (good) | 0 (0) | 4 (40) | 4 (6.8) | |
| 51-55.9 (excellent) | 0 (0) | 3 (30) | 3 (5.1) | |
| >55.9 (superior) | 49 (100) | 0 (0) | 49 (83.1) | |
| Total | 49 (100) | 10 (100) | 59 (100) | |

BMI: Body mass index, **Strongly significant (*P*≤0.01)

**Table 4:** Association of $VO_2$ max with BMI by Pearson's correlation

| Pair | Female | | Male | |
|---|---|---|---|---|
| | r | *P* | R | *P* |
| $VO_2$ max versus BMI ($kg/m^2$) | −0.895 | <0.001** | −0.646 | <0.001** |

BMI: Body mass index, ** Strongly significant ($P \leq 0.01$)

self-esteem. In the current obesity trend and increasing cardiovascular trend, it is advisable to restrict the calorie intake and to improve the physical fitness.[1]

In this study, we found statistically significant difference in $VO_2$ max value of male and female gender, $VO_2$ max value being more in male gender. Our study results correlated with the previous study which showed significant higher $VO_2$ max in male students as compared with female students. The study suggested females had a lower level of aerobic fitness as compared with male students.[7]

In this study, $VO_2$ max was significantly less in obese group as compared with nonobese group in both the genders. The correlation factor for association of BMI and $VO_2$ max was negative and it was statistically significant. In obese individuals, there is increase in Type II muscle fibers and decrease in type I muscle fibers which may have effect on reduced oxygen uptake.[6] Furthermore, there may be changes in the cardiovascular functions in severely overweight individuals. Greater the BMI, the functional impairment will be more severe.[1] Our study result correlates with the previous studies which showed a negative correlation between BMI and $VO_2$ max.[6,1] The results are in contrast with the previous study which showed a very low positive correlation between $VO_2$ max and BMI in physical education students. In the field of sports, the slightly higher body mass of an individual was helpful for storing more energy in the form of muscles glycogen/glucose and body fat for the more effective activity.[2]

In medical students, obesity is increasing due to lack of physical activity, more of sedentary lifestyle, and increase in energy dense food consumption. Obesity is associated with a decrease in physical fitness and increased risk of cardiovascular disease. Hence, the authors suggest that there should be more incorporation of routine exercise in daily life to increase the physical fitness and also develop healthy diet habits. The nonexercise test using NASA/Johnson Space Centre PA-R scale can be used to evaluate the physical fitness among medical students and motivate them to adapt healthier lifestyle modification.

## CONCLUSION

Increase in the BMI affects the physical fitness and causes decrease in the $VO_2$ max. There is a negative association between BMI and $VO_2$ max. Measuring $VO_2$ max by the NASA/Johnson space central physical activity rating (PA-R) scale is useful in knowing physical fitness of individuals in large scale studies. Lifestyle modification should be adopted in medical students to improve their fitness level and hence their work performance.

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